What is claimed is:

| | 1 | 1/A method of delivering a pressurized glass melt to a glass forming apparatus, |
|-----------------------------|----|---------------------------------------------------------------------------------------------|
| | 2 | comprising the step of: |
| | 3 | a) delivering said glass melt through a molten glass pump, such that an output of |
| | 4 | said glass melt is transferred to said glass forming apparatus; |
| | 5 | wherein said molten glass pump comprises: |
| | 6 | i) a housing having an entrance end for receiving an unpressurized glass |
| | 7 | melt and a distal output end for outputting a pressurized glass melt; |
| <u>.</u> | 8 | and |
| | 9 | ii) a rotating hub positioned within said housing, said rotating hub |
| IJ | 10 | including a centerline recirculation channel that traverses the length |
| | 11 | of said hub. |
| | 1 | 2. The method of claim 1, further comprising the step of: |
| The they start start start. | 2 | b) uptaking a cord portion of said glass melt at said distal output end through said |
| | 3 | centerline recirculation channel back towards said entrance end. |
| - | 1 | 3. The method of claim 2, further comprising the step of transporting and pressurizing said |
| | 2 | glass melt, wherein a plurality of auger flights extending radially from an external |
| | 3 | surface of said rotating hub move the molten glass from the inlet end to the distal |
| | 4 | end of the pump. |
| | 1 | 4. The method of claim 2, further comprising the step of: |
| | 2 | c) further comprising the step of transporting, pressurizing, and mixing said glass |
| | 3 | melt, wherein a plurality of auger flights extending radially from an |
| | 4 | external surface of said rotating hub move the molten glass from the inlet |
| | 5 | end to the distal end of the pump, include at least one cutout which allow a |
| | 6 | portion of said glass melt to pass backwards into another flow path thereby |
| | 7 | mixing said glass melt |
| | | |

| | 1 | 5. The method of claim 2, wherein multiple sets of blades radially attached to an external |
|--------------------------------|----|--------------------------------------------------------------------------------------------|
| | 2 | surface of said rotating hub divide a flow of glass melt exiting a first set of |
| | 3 | adjacent blades as it enters a passageway of a second set of adjacent blades. |
| | 1 | 6. The method of claim 2, wherein said molten glass pump further comprises a counter- |
| | 2 | rotating sleeve having a direction of rotation opposite to that of said rotating hub, |
| | 3 | said counter-rotating sleeve surrounding said rotating hub and being disposed |
| | 4 | within said housing with the purpose of eliminating the rotation of the molten glass |
| | 5 | stream exiting the molten glass pump. |
| | 1 | 7. The method of claim 6, further comprising the step of uptaking a peripheral portion of |
| 1 | 2 | said glass melt at said distal end of said molten glass pump back towards said |
| ıD | 3 | entrance end through a peripheral recirculation channel lying between said |
| | 4 | counter-rotating sleeve and said housing. |
| Q '9 | 1 | 8. The method of claim 2, wherein said molten glass pump further comprises: |
| | 2 | iii) a first stage including a plurality of auger flights extending radially from an |
| 10 | 3 | external surface of a first-half portion of said rotating hub, wherein said |
| | 4 | auger flights recirculate any poorly homogenized glass that flows off a tip |
| The Hall has diese the same in | 5 | of the auger flights back into a fluid stream of glass; and |
| | 6 | iv) a second stage including multiple sets of blades that are radially attached to an |
| | 7 | external surface of a second-half portion of said rotating hub, wherein any |
| | 8 | two adjacent sets of blades are positioned such that a flow of glass melt |
| | 9 | exiting a first set of adjacent blades is divided as it enters a passageway of a |
| 1 | .0 | second set of adjacent blades. |
| | 1 | 9. The method of claim 8, wherein said molten glass pump further comprises a counter- |
| | 2 | rotating sleeve having a direction of rotation opposite to that of said rotating hub, |
| | 3 | said counter-rotating sleeve surrounding said rotating hub and being disposed |
| | 4 | within said housing. |
| | 1 | 10. The method of claim 9, further comprising the step of uptaking a peripheral portion of |
| | 2 | said glass melt at said distal end of said molten glass pump through a peripheral |
| | | |

| 3 | recirculation channel lying between said counter-rotating sleeve and said housing |
|------------------------------------------------------|------------------------------------------------------------------------------------------|
| 4 | back towards said entrance end. |
| 1 | 11. The method of claim 8, wherein said plurality of auger flights comprise at least one |
| 2 | cutout that a portion of said glass melt to pass backwards into another flow path |
| 3 | thereby mixing said glass melt. |
| 1 | 12. A glass manufacturing system comprising: |
| 2 | a) a glass-melting furnace; |
| 3 | b) a fore hearth connected to said furnace; |
| <u> </u> | c) a molten glass pump connected to said fore hearth that pressurizes and |
| 5 | homogenizes an unpressurized glass melt into a pressurized glass melt, |
| <u>1</u> 6 | wherein said molten glass pump comprises: |
| 700 4 5 6 7 7 TO | i) a housing having an entrance end for receiving said unpressurized glass |
| 2 Q | melt and a distal output end for outputting said pressurized glass |
| 9 1 10 13 110 111 11 11 110 | melt; and |
| 14 | |
| 10 1 | ii) a rotating hub positioned within said housing, said hub comprising a |
| | centerline recirculation channel that traverses the length of said hub |
| 12 | wherein said centerline recirculation channel intakes a cord portion |
| 13 | of said glass melt at said distal output end and conducts said cord |
| 14 | portion through said centerline recirculation channel back towards |
| 15 | said entrance end; |
| 16 | d) a delivery tube to deliver said pressurized glass melt from said molten glass |
| 17 | pump; and |
| 18 | e) a glass-forming device for receiving said pressurized glass melt from said |
| 19 | delivery tube. |
| 1 | 13. The glass manufacturing system of claim 12, wherein said rotating hub further |
| 2 | comprises a plurality of auger flights extending radially from an external surface of |
| | - · |

| | 3 | said rotating hub, wherein said auger flights recirculate any poorly homogenized |
|---------------------------------|---|----------------------------------------------------------------------------------------|
| | 4 | glass that flows off a tip of the auger flights back into a fluid stream of glass. |
| | 1 | 14. The glass manufacturing system of claim 13, further comprising a counter-rotating |
| | 2 | sleeve having a direction of rotation opposite to that of said rotating hub, said |
| | 3 | counter-rotating sleeve surrounding said rotating hub and being disposed within |
| | 4 | said housing. |
| | 1 | 15. The glass manufacturing system of claim 14, further comprising a peripheral |
| | 2 | recirculation channel lying between said counter-rotating sleeve and said housing, |
| | 3 | wherein a peripheral portion of said glass melt at said distal end of said molten |
|] | 4 | glass pump is conducted through the peripheral recirculation channel back towards |
| Sec. Sec. 4nd 4nd 4nd 11nd 11nd | 5 | said entrance end. |
| j | 1 | 16. The glass manufacturing system of claim 12, wherein said rotating hub further |
|] | 2 | comprises a plurality of auger flights extending radially from an external surface of |
| j | 3 | said rotating hub, wherein said plurality of auger flights include at least one cutout |
| 1 | 4 | that allows a portion of said glass melt to pass backwards into another flow path |
| , | 5 | thereby mixing said glass melt. |
| | 1 | 17. The glass manufacturing system of claim 16, further comprising a counter-rotating |
| • | 2 | sleeve having a direction of rotation opposite to that of said rotating hub, said |
| | 3 | counter-rotating sleeve surrounding said rotating hub and being disposed within |
| | 4 | said housing. |
| | 1 | 18. The glass manufacturing system of claim 17, further comprising a peripheral |
| | 2 | recirculation channel lying between said counter-rotating sleeve and said housing, |
| | 3 | wherein a peripheral portion of said glass melt at said distal end of said molten |
| | 4 | glass pump is conducted through the peripheral recirculation channel back towards |
| ; | 5 | said entrance end. |
| | l | 19. The glass manufacturing system of claim 12, wherein said rotating hub further |
| 2 | 2 | comprises multiple sets of blades radially attached to an external surface of said |
| 3 | 3 | rotating hub, wherein any two adjacent sets of blades are positioned such that a |

| | 4 | flow of glass melt exiting a first set of adjacent blades is divided as it enters a |
|-----------------------------------------|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | 5 | passageway of a second set of adjacent blades. |
| | 1 | 20. The glass manufacturing system of claim 19, further comprising a counter-rotating |
| | 2 | sleeve having a direction of rotation opposite to that of said rotating hub, said |
| | 3 | counter-rotating sleeve surrounding said rotating hub and being disposed within |
| | 4 | said housing. |
| | 1 | 21. The glass manufacturing system of claim 20, further comprising a peripheral |
| | 2 | recirculation channel lying between said counter-rotating sleeve and said housing, |
| | 3 | wherein a peripheral portion of said glass melt at said distal end of said molten |
| 7 | 4 | glass pump is conducted through the peripheral recirculation channel back towards |
| Company of the second | 5 | said entrance end. |
| | 1 | 22. The glass manufacturing system of claim 19, wherein said blades are pitched in one |
| 40 | 2 | direction. |
| IJ | 1 | 22. The class warm 6 of the control |
| | 2 | 23. The glass manufacturing system of claim 19, wherein said blades have different |
| 10 | 2 | lengths. |
| 19. 19. 19. 19. 19. 19. 19. 19. 19. 19. | 1 | 24. The glass manufacturing system of claim 19, wherein said blades are arranged in a |
| | 2 | helical pattern around said rotating hub. |
| | 1 | 25. The glass manufacturing system of claim 19, wherein said blades of a first set of |
| | 2 | adjacent blades overlap with that of a second set of adjacent blades. |
| | | as a second set of adjacent blades. |
| | 1 | 26. The glass manufacturing system of claim 19, wherein said blades are pitched in two |
| | 2 | directions and at varying pitches |
| | 1 | 27. The glass manufacturing system of claim 19, wherein said blades are arranged with |
| 2 | 2 | varied spacing between said blades. |
| | _ | |
| | 1 | 28. The glass manufacturing system of claim 12, further comprising a counter-rotating |
| | 2 | sleeve having a direction of rotation opposite to that of said rotating hub, said |
| 3 | | counter-rotating sleeve surrounding said rotating hub and being disposed within |
| 4 | ŧ. | said housing. |

| | 1 | 29. The glass manufacturing system of claim 28, further comprising a peripheral |
|----------------------------|----|-----------------------------------------------------------------------------------------|
| | 2 | recirculation channel lying between said counter-rotating sleeve and said housing, |
| | 3 | wherein a peripheral portion of said glass melt at said distal end of said molten |
| | 4 | glass pump is conducted through the peripheral recirculation channel back towards |
| | 5 | said entrance end. |
| | 1 | 28. The glass manufacturing system of claim 12, wherein said molten glass pump further |
| | 2 | comprises: |
| | 3 | a) a first stage including a plurality of auger flights extending radially from an |
| | 4 | external surface of a first-half portion of said rotating hub, wherein said |
| 1 | 5 | auger flights recirculate any poorly homogenized glass that flows off a tip |
| | 6 | of the auger flights back into a fluid stream of glass; and |
| C. c. c. c. c. c. 11 C. C. | 7 | b) a second stage including multiple sets of blades that are radially attached to an |
| 0 U | 8 | external surface of a second-half portion of said rotating hub, wherein any |
| Ū | 9 | two adjacent sets of blades are positioned such that a flow of glass melt |
| 3 | 10 | exiting a first set of adjacent blades is divided as it enters a passageway of a |
| | 11 | second set of adjacent blades. |
| | 1 | 29. The glass manufacturing system of claim 12, further comprising a counter-rotating |
| i. | 2 | sleeve having a direction of rotation opposite to that of said rotating hub, said |
| | 3 | counter-rotating sleeve surrounding said rotating hub and being disposed within |
| | 4 | said housing. |
| | 1 | 30. The glass manufacturing system of claim 29, further comprising a peripheral |
| | 2 | recirculation channel lying between said counter-rotating sleeve and said housing, |
| | 3 | wherein a peripheral portion of said glass melt at said distal end of said molten |
| | 4 | glass pump is conducted through the peripheral recirculation channel back towards |
| | 5 | said entrance end. |
| | 1 | 31. The glass manufacturing system of claim 28, wherein said plurality of auger flights |
| | 2 | comprise at least one cutout that allows a portion of said glass melt to pass |
| | 3 | backwards into another flow path thereby mixing said glass melt. |
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| | 1 | 2. A month glass pump for pressurizing and homogenizing a glass melt, comprising: |
|---------------------------------|---|-----------------------------------------------------------------------------------------|
| | 2 | a) a housing having an entrance end for receiving an unpressurized glass melt and |
| | 3 | a distal output end for outputting a pressurized glass melt; and |
| | 1 | b) a rotating hub positioned within said housing, said hub comprising a centerline |
| | 2 | recirculation channel that traverses the length of said hub, wherein said |
| | 3 | centerline recirculation channel intakes a cord portion of said glass melt at |
| | 4 | said distal output end and conducts said cord portion through said |
| | 5 | centerline recirculation channel back towards said entrance end. |
| - | 1 | 33. The molten glass pump of claim 32, wherein said rotating hub further comprises a |
| g | 2 | plurality of auger flights extending radially from an external surface of said |
| 10 | 3 | rotating hub, wherein said auger flights recirculate any poorly homogenized glass |
| den den des den 11 de de de des | 4 | that flows off a tip of the auger flights back into a fluid stream of glass. |
| m. m. | 1 | 34. The molten glass pump of claim 33, further comprising a counter-rotating sleeve |
| 3 | 2 | having a direction of rotation opposite to that of said rotating hub, said counter- |
| T | 3 | rotating sleeve surrounding said rotating hub and being disposed within said |
| the the that the the first of | 4 | housing. |
| | 1 | 35. The molten glass pump of claim 34, further comprising a peripheral recirculation |
| | 2 | channel lying between said counter-rotating sleeve and said housing, wherein a |
| | 3 | peripheral portion of said glass melt at said distal end of said molten glass pump is |
| | 4 | conducted through the peripheral recirculation channel back towards said entrance |
| | 5 | end. |
| | 1 | 36. The molten glass pump of claim 32, wherein said rotating hub further comprises a |
| | 2 | plurality of auger flights extending radially from an external surface of said |
| | 3 | rotating hub, said plurality of auger flights including at least one cutout that allows |
| | 4 | a portion of said glass melt to pass backwards into another flow path thereby |
| | 5 | mixing said glass melt. |
| | 1 | 37. The molten glass pump of claim 36, further comprising a counter-rotating sleeve |
| | 2 | having a direction of rotation opposite to that of said rotating hub, said counter- |
| | | |

| 3 | rotating sleeve surrounding said rotating hub and being disposed within said housing. |
|---|----------------------------------------------------------------------------------------------------------------------|
| 1 | |
| 2 | 38. The molten glass pump of claim 37, further comprising a peripheral recirculation |
| 3 | channel lying between said counter-rotating sleeve and said housing, wherein a |
| 4 | peripheral portion of said glass melt at said distal end of said molten glass pump is |
| 5 | conducted through the peripheral recirculation channel back towards said entrance end. |
| 1 | |
| 2 | 39. The molten glass pump of claim 32, wherein said rotating hub further comprises |
| 3 | multiple sets of blades radially attached to an external surface of said rotating hub, |
| 4 | wherein any two adjacent sets of blades are positioned such that a flow of glass |
| 5 | melt exiting a first set of adjacent blades is divided as it enters a passageway of a second set of adjacent blades. |
| 1 | 40. The molten glass pump of claim 39, further comprising a counter-rotating sleeve |
| 2 | having a direction of rotation opposite to that of said rotating hub, said counter- |
| 3 | rotating sleeve surrounding said rotating hub and being disposed within said |
| 4 | housing. |
| 1 | 41. The molten glass pump of claim 40, further comprising a peripheral recirculation |
| 2 | channel lying between said counter-rotating sleeve and said housing, wherein a |
| 3 | peripheral portion of said glass melt at said distal end of said molten glass pump is |
| 4 | conducted through the peripheral recirculation channel back towards said entrance |
| 5 | end. |
| 1 | 42. The molten glass pump of claim 39, wherein said blades are pitched in one direction. |
| 1 | 43. The molten glass pump of claim 39, wherein said blades have different lengths. |
| 1 | 44. The molten glass pump of claim 39, wherein said blades are arranged in a helical |
| 2 | pattern around said rotating hub. |
| l | 45. The molten glass pump of claim 39, wherein said blades of a first set of adjacent |
| 2 | blades overlap with that of a second set of adjacent blades. |

and the first that the tree that the second the second that the second the second that the second t

| | 1 | 46. The molten glass pump of claim 39, wherein said blades are pitched in two directions |
|---------------------------------|----|------------------------------------------------------------------------------------------------------------------------------------|
| | 2 | and at varying pitches |
| | 1 | 47. The molten glass pump of claim 39, wherein said blades are arranged with varied |
| | 2 | spacing between said blades. |
| | 1 | 48. The molten glass pump of claim 32, wherein said rotating hub further comprises: |
| | 2 | a) a first stage including a plurality of auger flights extending radially from an |
| | 3 | external surface of a first-half portion of said rotating hub, wherein said |
| | 4 | auger flights recirculate any poorly homogenized glass that flows off a tip |
| 2= | 5 | of the auger flights back into a fluid stream of glass; and |
| | 6 | b) a second stage including multiple sets of blades that are radially attached to an |
| *# == | 7 | external surface of a second-half portion of said rotating hub, wherein any |
| 45 | 8 | two adjacent sets of blades are positioned such that a flow of glass melt |
| | 9 | exiting a first set of adjacent blades is divided as it enters a passageway of a |
| | 10 | second set of adjacent blades. |
| | | second set of adjacent blades. |
| the true that the true that the | 1 | 49. The molten glass pump of claim 32, further comprising a counter-rotating sleeve |
| | 2 | having a direction of rotation opposite to that of said rotating hub, said counter- |
| 1l | 3 | rotating sleeve surrounding said rotating hub and being disposed within said |
| | 4 | housing. |
| | 1 | 50. The molten glass pump of claim 49, further comprising a peripheral recirculation |
| | 2 | channel lying between said counter-rotating sleeve and said housing, wherein a |
| | 3 | peripheral portion of said glass melt at said distal end of said molten glass pump is |
| | 4 | conducted through the peripheral recirculation channel back towards said entrance |
| | 5 | end. |
| | 1 | 51. The molten glass pump of claim 48, wherein said plurality of auger flights comprise at |
| | 2 | · · |
| | 3 | least one cutout that allows a portion of said glass melt to pass backwards into another flow path thereby mixing said glass melt. |
| | | |